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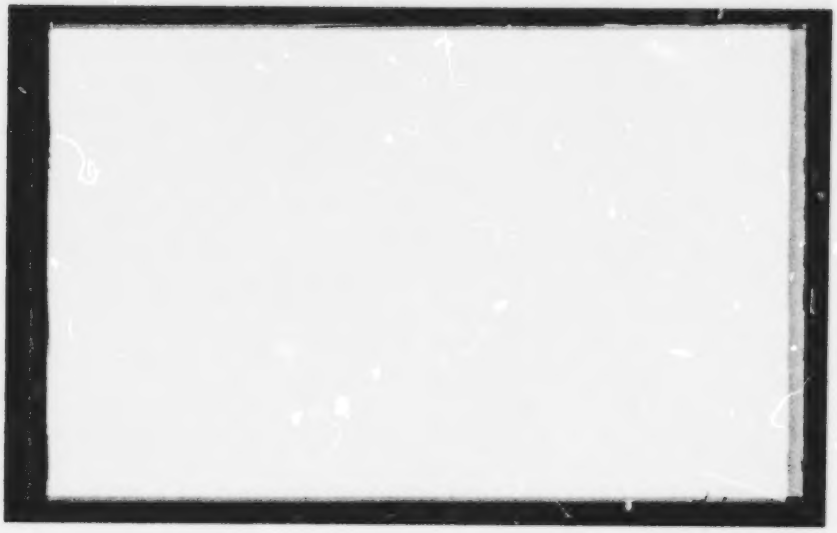

CENTRE DE RECHERCHE SUR LES TRANSPORTS

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IMPLEMENTATION OF EQUILIBRIUM TRAFFIC ASSIGNMENT WITH GRAPHICAL OUTPUT IN THE GVRD BIMODAL MODEL

by

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IMPLEMENTATION OF EQUILIBRIUM TRAFFIC ASSIGNMENT WITH GRAPHICAL OUTPUT IN THE GVRD BIMODAL MODEL

Purpose

To perform an equilibrium traffic assignment of auto drivers and passengers on the Vancouver road network. To provide graphical output of the resulting predicted road link volumes and to make the link volumes (and times) available to the GVRD report programs. The road network may also be plotted without the volumes for verification purposes.

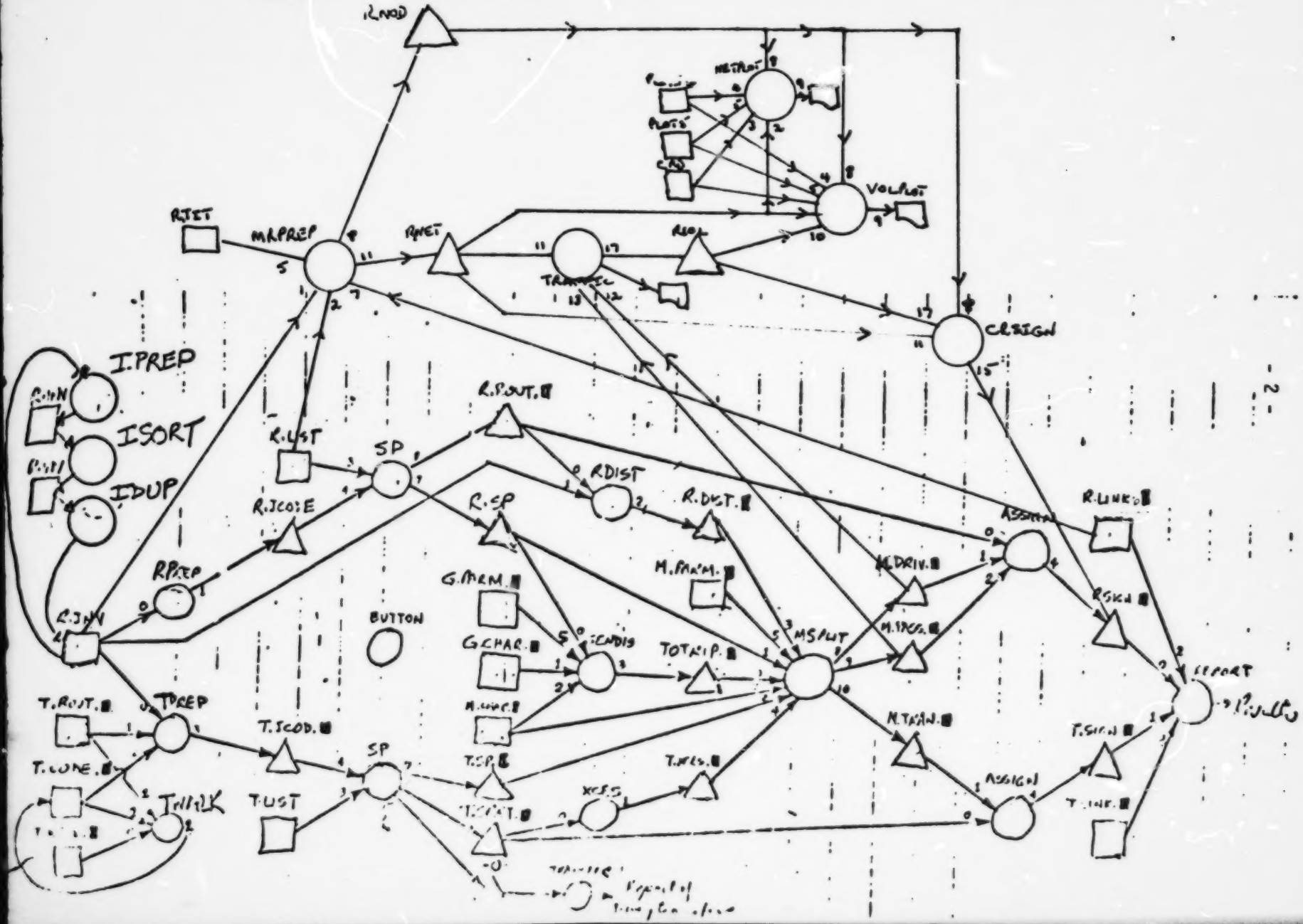
1. Introduction

The equilibrium traffic assignment package contains a program (MRPREP) to interface the GVRD road inventory (R.INV) and screen line (R.LINK) files with the equilibrium traffic assignment program (TRAFFIC), and a program CRSIGN to convert the output produced by TRAFFIC to the GVRD file RSIGN which can then be read by the GVRD report programs. Intermediate files which are produced by the equilibrium traffic assignment package are used by the two graphics programs NETPLOT and VOLPLOT which produce a plot of the network,and a plot of the network showing the traffic volume predicted by TRAFFIC, respectively. Figure 1.1 shows the GVRD bimodal model with the equilibrium assignment package and graphics programs shown in red. The package and the graphics programs and their operation are described in the following sections.

2. Equilibrium assignment package

An overview of the package is shown in Figure 2.1 The notation is that used

Figure 1.1 GVRD bimodal model with equilibrium assignment package and graphics programs



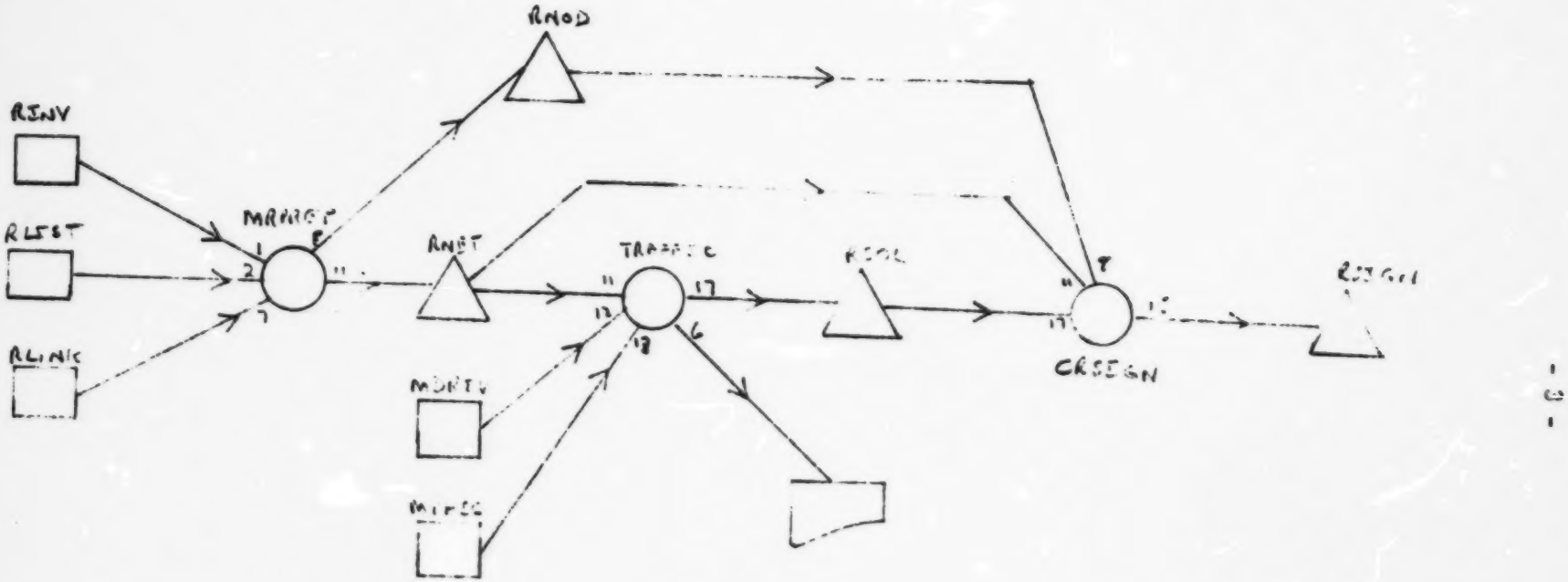


Figure 2.1 Equilibrium assignment package

by the GVRD i.e. circles indicate programs, squares indicate user supplied data, triangles indicate intermediate files. In addition reports are shown by . Work files are excluded.

The package is executed using the control cards shown in Figure 2.2 in which the files have been assigned names as follows:

File	Name in control cards
RINV	URGV:R.INV5
RLIST	URGV:R.LIST.2
RLINK	URGV:R.LINK.6
RTIT	TITVAN.D
RNET	VANNET.D
RNOD	VANNOD.D
MDRIV	URGV:LY.DRIV
MPASS	URGV:LY.PASS
RSOL	SOLVAN.D.
RSIGN	RSIGNVAN.D

The equilibrium assignment package consists of 3 basic programs:

- MRPREP front end interface program
- TRAFFIC equilibrium traffic assignment
- CRSIGN back end interface program

Outlines of these programs follow, detailed descriptions can be found in Appendix C

```
RUNTRAF
                                                    AT 18:11:24 ON JUL 11, 1978 FOR CCID = URI
$STATION NOTM P=150 T=80
[redacted]
$RUN MERGEP.O 1=URGV:R.INV5 2=URGV:P.LIST.2 7=URGV:R.LINK.5 3=-3 9=-9 8=NODVAN.D 6=-6
$RUN *SORT
SORT=C,A,6,4,C,A,11,4
INPUT=-3,F,51,51
OUTPUT=-10,F,81,51
END
$RUN MERGEN.O 10=-10 5=TITVAN.D 9=-9 11=NETVAN.D
$RUN TRAFFIC.O 11=NETVAN.D 12=URGV:LY.DRIV 16=-16 18=-18 17=SOLVAN.D 8=NODVAN.D 13=URGV:LY.PASS 19=-19
$RUN CRSIGN.O 11=NETVAN.D 8=NODVAN.D 17=SOLVAN.D 15=RSIGNVAN.D
$SIGNOFF
```

Figure 2.2 Control cards to run equilibrium assignment package

2.1 MRPREP Front end interface

This program creates a road network file (RNET), suitable for input to TRAFFIC, from the GVRD road inventory file (R.INV) and centroid list (R.LIST). It also picks up the observed volume from the screen line file (RLINK). These volumes are used in the TRAFFIC report only. They do not influence the assignment. The title, comment and parameter cards required by TRAFFIC are copied from file RTIT. For details on the contents of RTIT see 2.2 TRAFFIC. MRPREP also produces another file which contains a list of the GVRD node identifiers transformed into an internal packed form. (See Appendix A for details of the transformation) MRPREP renumbers the nodes for TRAFFIC in the order: centroids, turning nodes (1205FNI etc), other road nodes. The list on file RNOD contains the GVRD identifiers in this order.

MRPREP assumes that the identifiers follow the node numbering system described in the GVRD Transportation Model - Data coding procedures dated Nov. 22, 1977. That is the first 4 characters are assumed to be numeric (municipality and RDS) and are followed by a node identifier which may be 0-9, A-Z. File RINV must be sorted by link origin node name (char 1-8)

The format of the files RNET and RNOD are shown in appendix B.

MRPREP transfers the following data directly from file RINV to file RNET

Link length

Number of lanes (divided by 2)

Observed travel time

The observed travel speed is calculated from the distance and the observed

time. The observed volume is transferred from the screen line file RLINK for those links included in screen lines.

The delay function number and free flow speed are determined from the function and traffic signal specifications as described in Appendix C. (subroutine DELFN)

2.2 TRAFFIC Equilibrium traffic assignment

The TRAFFIC program provided is based on the program TRAFFIC described in "TRAFFIC. An equilibrium assignment program"*. The program provided to the GVRD contains improved code and also the code in COST and SUMTRAV applicable to the delay curves developed for the GVRD. This version also assigns passengers as well as drivers.

The input and output files are as described in the publication mentioned above with the following changes:

a) Network data cards

cc44-46 I3 Link type is not used.

cc48-50 I3 contains the free flow speed for the link (mph x 10) as determined in MRPREP.

b) OD matrix

This file format is that of GVRD file M.DRIV In addition an OD matrix of passengers having the same format is also assigned.

c) Solution file

Following record k

---

* Publication # 17, Centre de recherche sur les transports, Université de Montréal.

Records k+1 to ℓ : Format 10F8.0. Cumulated volume of passengers on each link for the solution at termination.

ℓ = number of links / 10 + k + 1

Note that the title cards, comment card and parameters card are copied to RNET from RTIT. Any changes should therefore be made in file RTIT. For details of these cards see the TRAFFIC publication.

2.3 CRSIGN Back end interface

This program transforms the predicted link volumes and times, output from TRAFFIC (file RSOL), into a file with the format of the GVRD file RSIGN which can then be used with the GVRD program REPORT.

CRSIGN also reads the TRAFFIC road network file RNET to create the necessary network description vectors, and the node list file RNOD to retrieve the GVRD identifiers. For more details see Appendix C.

3. Computer graphics programs

The plot programs which produce graphical displays of the vehicle network (NETPLOT.O), and predicted link flows (VOLPLOT.O) are run independently from the assignment programs. Both plot programs require node coordinate information and in addition the volume plot requires the solution file generated by TRAFFIC.

3.1 Run commands

a) Network plot:

```
$RUN NETPLOT.O 2=NETVAN.D 3=VANCRD.D 4=PLOT4.D 5=PLOT5.D 8=NODVAN.D
9=-PLOT
```

b) Volume plot:

```
$RUN VOLPLOT.O 2=NETVAN.D 3=VANCRD.D 4=PLOT4.D 5=PLOT5.D 8=NODVAN.D
9=-PLOT 10=VANVOL.D
```

To obtain a plot, the plot file -PLOT is transmitted to the plot queue as follows:

```
$RUN PLOT:Q PAR=-PLOT LARGE BLANK
```

NETVAN.D,NODVAN.D and VANVOL.D are intermediate files generated by the assignment program. PLOT4.D, PLOT5.D and VANCRD.D are user supplied files described in detail below.

3.2 Network geo-coding

In order to plot the network, each node must be assigned (x,y) coordinates with respect to some arbitrary coordinate system: these may be most easily obtained by digitizing a network map. (Because of the time constraints, only a partial set of node coordinates has been

provided). Information relating to the coordinate scale is contained in the variable UNIT in common block /GEOUN/ of the BLOCK DATA sub-program of each plot program. UNIT specifies the number of coordinate units per mile and may be modified by the user. For example suppose the unit for measuring distance on the network map is (1/100)". The node coordinate (1552, 2207) implies that the node has coordinates (15.52", 22.07") with respect to the chosen reference system. If the map scale is 1:50 000, 1 mile is represented on the map by 1.2672" or 126.72 coordinate units. i.e. UNIT = 126.72.

A given set of coordinates must nave the same scale: if maps for different regions of the network are at different scales the coordinates for each region must be transformed to produce a final set at the same scale.

3.3 Features of the plot programs

The area to be plotted is defined by the user and is contained within a rectangle inclined at an angle θ to the x-axis of the coordinate system implicit in the node coordinate data. (Fig. 3.1). The rectangle is completely defined by four nodes, one on each side of the rectangle, and θ. A rectangle internal to this region, defined in a similar manner, may be optionally omitted from the plot. The plot size is determined by nodes P_i i=1,...,4 and the plot scale which is user specified. (The plot height is limited to 28.5": 2.5" is reserved at the top of the plot for printing the title, scale and a north direction arrow).

For the vehicle network, a pair of connected nodes is joined by a solid

line with a directional arrow located at its midpoint if the corresponding link is one-way. Node numbers are drawn parallel to the x-axis. Centroid connectors are indicated as dashed lines.

In the vehicle volume plot, connected nodes are joined by dashed lines to indicate the network structure. A link volume is represented by a solid rhomboidal segment, the width of the segment indicating the volume assigned to the link. The traffic volume is printed at the midpoint of the segment. On centroid connectors, volume numbers only are plotted.

3.4 User supplied input files

a) Unit 4

The file referenced by unit 4 contains one record specifying the title to be printed on the plot. First entry of record is the number of characters in title, followed by title in (I5,60A1) format. The title is left justified and can contain up to 60 characters.

b) Unit 5

This file specifies plot parameters.

Record 1: MX1, MXA, MX2, MXB, MY1, MYA, MY2, MYB

Record 2: JX1, JXA, JX2, JXB, JY1, JYA, JY2, JYB

Records 1 and 2 define area to be plotted as indicated in Fig.3.1. MX1 and MXA define the node at location P_1 etc. MX1 is the 4 digit numerical component of the node and MXA is the alphanumeric component. The format is 4(1X, I4, A1). If no region internal to the plot area is to be omitted from the plot, JX1 is set to zero.

Record 3: SCALE, ANGROT, ANGNOR (1X, 3F10.0)

SCALE : desired scale of plot (ft./in.)

ANGROT : angle of rotation (counter clockwise sense) of plot axes with respect to coordinate axes (designated as θ in Fig. 3.1)

ANGNOR : angle of north direction indicator to x-axis in counter clockwise sense.

Record 4: VMAX (1X, F10.0)

VMAX is an upperbound for the link volumes. It is only required for the volume plot.

c) Unit 3

This file contains the node coordinates. Each record specifies a node and its x and y coordinates in (1X, I4, A1, 2I5) format. Units 2, 8 and 10 reference intermediate files generated by the assignment programs. Unit 9 contains the output plot file.

3.5 Example test input

Unit 4: PLOT4.D

```
12TEST NETWORK
```

Unit 5: PLOT5.D

```
1120 12010 12020 1140
  0
1500.   0.    0.
3000.
```

Unit 3: TCOORD.D

```
120201230012000
 11201200!2300
120101260012300
 11401230012600
1202A1230012100
1202D1220012200
1202C1230012200
1202B1230012200
 11211210012300
 11221220012300
 114C1230012300
1201C1240012300
1201B1250012300
 11231220012400
 114B1230012400
1201D1240012400
 114A1230012500
```

The network generated in the assignment run is stored in NETTEST.D. NODTEST.D. contains the node correspondance table and is generated in the assignment run. TESTVOL.D contains the predicted link volumes produced by the assignment. The run commands are

```
$RUN NETPLOT.O 2=NETTEST.D 3=TCOORD.D 4=PLOT4.D 5=PLOT5.D
8=NODTEST.D 9=-PLOT
$RUN PLOT:Q PAR=-PLOT LARGE BLANK

$RUN VOLPLOT.O 2=NETTEST.D 3=TCOORD.D 4=PLOT4.D 5=PLOT5.D
8=NODTEST.D 9=-PLOT 10=TESTVOL.D
$RUN PLOT:Q PAR=-PLOT LARGE BLANK
```

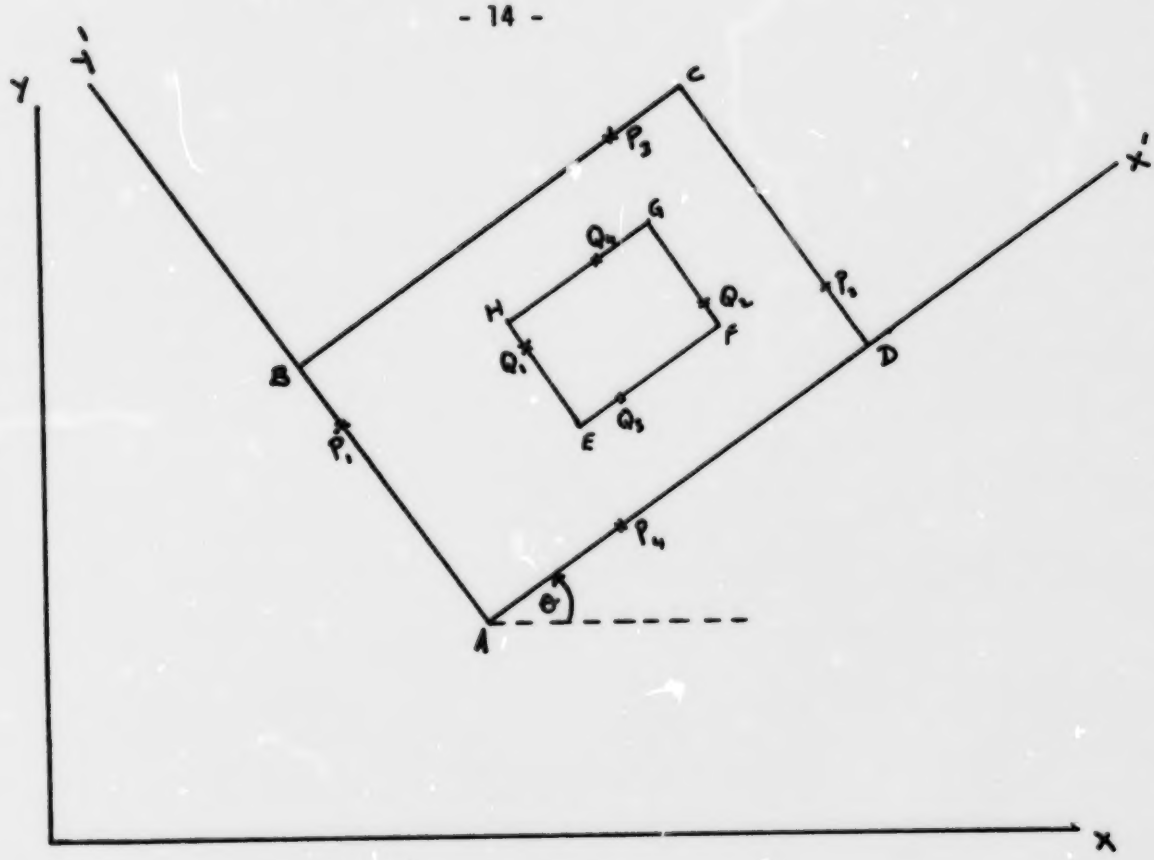
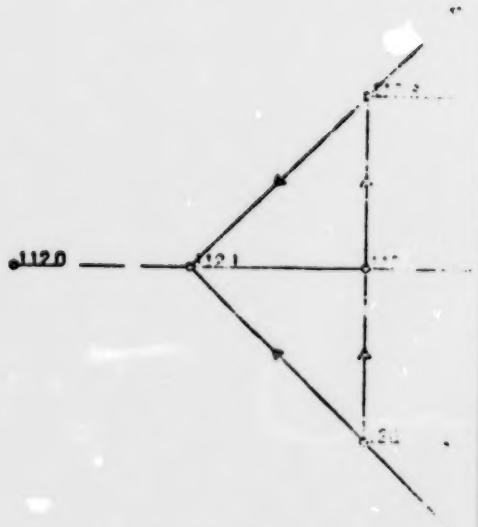


Fig.3.1 The points P_i, i=1,...,4 define the rectangle ABCD to be plotted. Q_i, i=1,...,4 define rectangle EFGH to be omitted. θ is the angle of rotation, counterclockwise sense, of the plot x-axis with respect to the x-axis of the reference system used for geocoding.

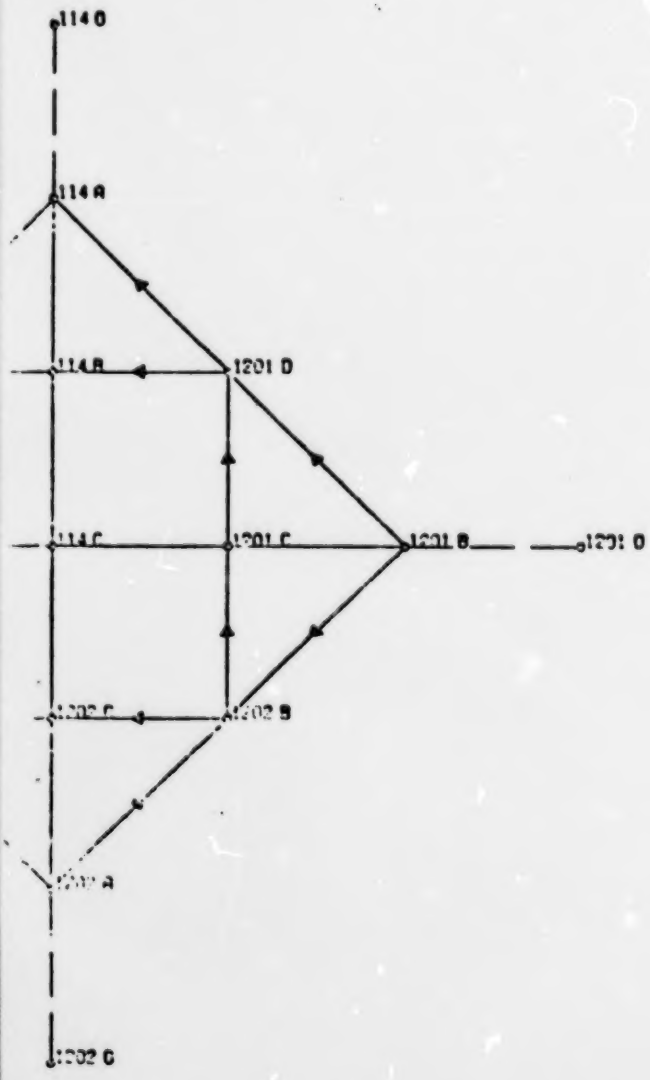
TEST NETWORK



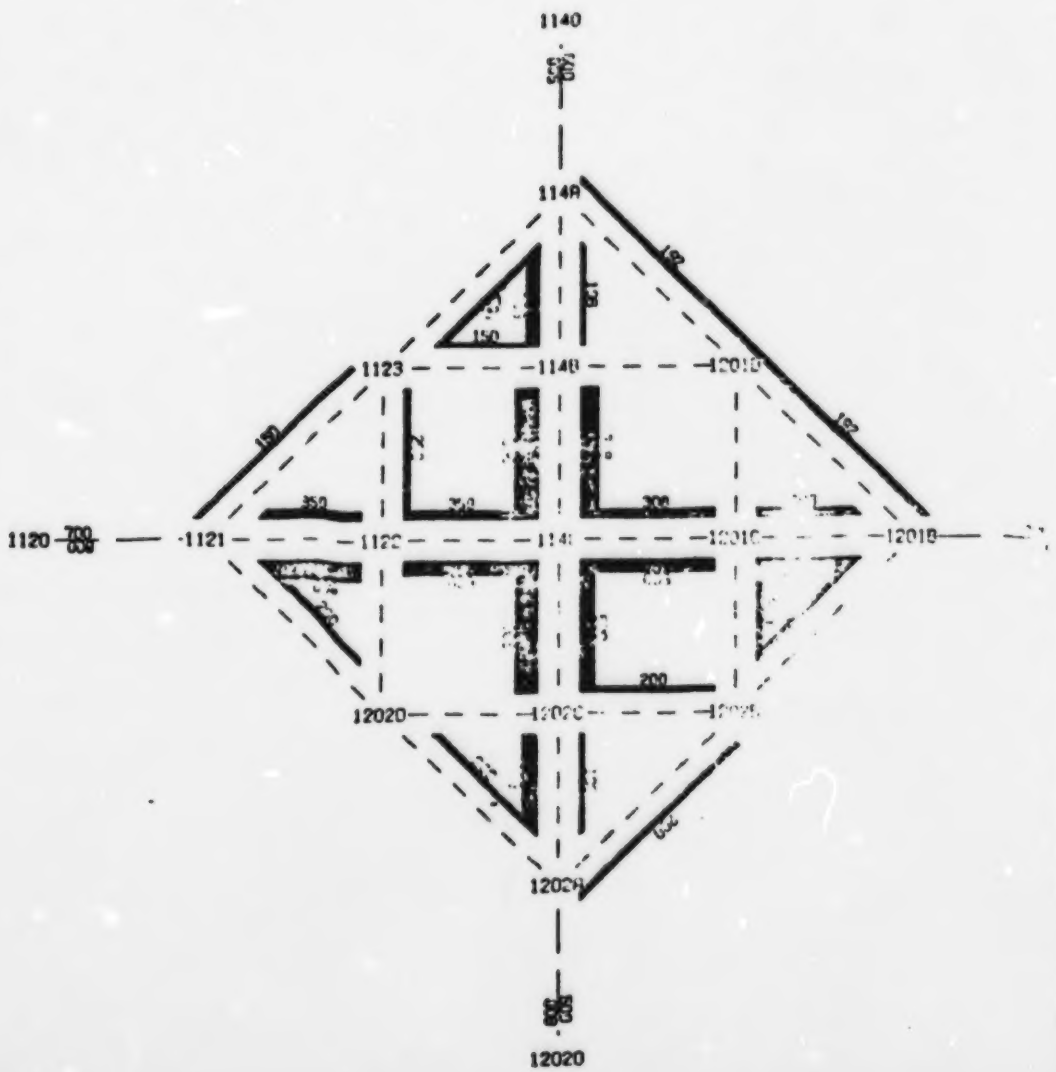
JUNE 25 1978

SCALE

FEET 400 0 400

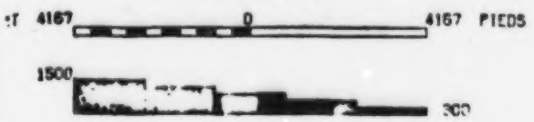


TEST NETWORK JUNE 2



1978

SCALE



APPENDIX A - Transformation of node numbers

This transformation is made in order to ease the task of renumbering the nodes for TRAFFIC. It does not imply any changes in existing GVRD programs and is described in case it is necessary to understand its use in programs MRPREP, CRSIGN, TRAFFIC, NETPLOT and VOLPLOT.

GVRD nodes are identified as follows (ref. Data Coding Procedures dated Nov. 22, 1976).

mmrrn Road nodes

or mmrrntt Turning nodes

where mm is the municipality code (numeric)

rr is the RDS code (numeric)

n is the node identifier within the municipality and RDS (0-9,A-Z)

tt is the turning node identifier (NI, NO, SI, SO, WI, WO, EI, EO)

A road node is considered, for the transformation, to have a similar format to a turning node with tt set to 2 blanks.

The transformation of mmrrntt is made as follows:

n is converted to a 2 digit number NN according to the table in vector ALPHAM, that is a conversion:

n	A	B	C	...	L	M	N	...	Z	0	1	2	...	8	9
NN	1	2	3	...	12	13	14	...	26	30	31	32	...	38	39

tt is converted to a 1 digit number N according to the table in vector MINIID, that is a conversion

tt	SI	NO	WI	EO	NI	SO	EI	WO
T	1	2	3	4	5	6	7	8

which corresponds to a clockwise numbering for an intersection with turning nodes. If tt is blank, T = 0

The final transformed node identifier is formed as follows:

= (mmrr x 1000) + (NN x 10) + T

For example node 12010 is transformed to 1201300; node 1203FWI to 1203063.

APPENDIX B

Descriptions for the following files are included here

RTIT
RNET
RNOD
RSOL

The files used by TRAFFIC are described in the TRAFFIC publication * with the modifications noted in section 2.2 of this document. The files used by the plot programs are described in section 3 of this document.

In the following cc indicates columns

* "TRAFFIC. An Equilibrium Assignment Program". Publication # 17, Centre de recherche sur les transports, Université de Montréal.

File: RTIT

Record 1:

cc 1-4 A4 'TIT1'

cc 6-45 10A4 Text for first title line of TRAFFIC report

Record 2:

cc 1-4 A4 'TIT2'

cc 6-65 15A4 Text for second title line of TRAFFIC report

Record 3:

cc 1-80 Text of comment

Note: This card forms the first record of files RSOL and RSIGN and should identify the particular assignment.

Record 4:

cc 1-4 A4 'PARM'

cc 6-45 TRAFFIC algorithm and program parameters. (See pages 7 and 12 of TRAFFIC publication).

File: RNET

Records 1 - 4 Copied from records 1 - 4 of the RTIT

Record 5: Network size card

cc 1 - 4 A4 'SIZE'

cc 6-10 I5 Number of nodes (including centroids) in road network

cc 11-15 I5 Number of links in road network

cc 16-20 I5 Number of centroids in road network

cc 21-25 I5 Number of turning nodes + centroids (i.e. highest turning node number)

Records 6 - L Network data cards. 1 card for each link.

cc 1 - 5 Identification (not checked)

cc 6 - 9 I4 Link origin node number

cc 11-14 I4 Link destination node number

cc 16-19 I4 Link length (miles x 100)

cc 21-23 I3 Number of lanes x 10

cc 24-25 I2 Delay function number

cc 27-30 I4 Observed travel speed (mph x 10)

cc 32-36 I5 Observed travel time (mins x 100)

cc 38-42 I5 Observed volume

cc 48-50 I3 Free flow speed (mph x 10)

L = number of links in road network + 5

File: RNOD

1 record for all node identifiers including centroids and turning nodes.

Unformatted.Length = (number of nodes + 1) x 4.

Record format:

Word 1	I*4	Number of node identifiers (i.e. number of nodes)
Words 2 to n + 1	I*4	Identifier of nodes 1 - n in packed internal format as described in APPENDIX A

The sequence of nodes 1-n is
- centroids
- turning nodes
- road nodes

File: RSOL

Record 1: Length 80 bytes

20 words 10A4 Comment from file RTIT, record 3

Record 2:

Word 1 I*4 Total number of nodes icluding centroids (NNODE)

Word 2 I*4 Number of centroids (NCENT)

Word 3 I*4 Number of links (NLINK)

Word 7A4 Time and date of run in characters

Word 11 A4 'SIN2' indicating drivers and passengers assigned.

Record 3: Length NLINK*2 bytes

Vector IDEST(L), L = 1, NLINK

IDEST(L) I*2 contains destination node of link L in TRAFFIC sequence.

Record 4: Length NNODE*4 bytes

Vector JSTART(I), I = 1, NNODE.

JSTART(I) I*4 contains link numbers in TRAFFIC sequence of first link with origin node I

Record 5: Length NNODE*4 bytes

Vector JEND(I), J = NNODE

JEND(I) I*4 contains link number in TRAFFIC sequence of last node with origin node I.

Record 6: Length NNODE*2 bytes

Vector IORD(I), I = 1, NNODE

IORD(I) I*2 contains sequence number of node I in final pointout i.e. in order by GVRD identifiers

. . . /

Record 7: Length NNODE*8 bytes

Vector IDENT(N), N = 1, NNODE.

IDENT(N) REAL*8 contains GVRD identifier of node N in TRAFFIC node sequence.

Record 8: Length NLINK*4 bytes

Vector ATRIP(L), L = 1, NLINK

ATRIP(L) REAL*4 contains number of drivers (vehicles) assigned to link L in TRAFFIC link sequence.

Record 9: Length NLINK*4 bytes

Vector PTRIP(L), L = 1, NLINK

PTRIP(L) REAL*4 contains number of passengers assigned to link L in TRAFFIC link sequence.

Record 10: Length NLINK*4 bytes

Vector TRAV(L), L = 1, NLINK

TRAV(L) REAL*4 contains the predicted travel time for link L in TRAFFIC sequence.

APPENDIX C

This appendix contains the following program descriptions:

C.1.	MRPREP	Front end interface for equilibrium assignment.
C.1.1	DELFN	Subroutine to determine delay function
C.2.	TRAFFIC	
C.2.1		User routines - UCOST SSTRAV, OBJCNS BLOCK DATA
C.2.2		Subroutine NULAFX
C.3	CRSIGN	Back end interface for equilibrium assignment.

C.1 Program: MRPREP

PURPOSE : Create a road network file in TRAFFIC format from GVRD files.

INPUT : 1) File name: RINV

Type : GVRD

Contents : Inventory file of transit and road links

Sequence : Sorted by link origin node

Unit # : 1

2) File name: RLIST

Type : GVRD

Contents : List of centroids

Sequence : Sorted by centroid identifier

Unit # : 2

3) File name: RLINK

Type : GVRD

Contents : Screen line links with observed volumes

Sequence : Sorted by screen line number

Unit # : 7

4) File name: RTIT

Type : User supplied

Contents : Titles, comment and parameters for TRAFFIC

Sequence : See file description in Appendix B

Unit # : 5

OUTPUT : 1) File name: RNOD

Type : Intermediate file

Contents : Vector of transformed GVRD node identifiers

Sequence : 1 record only

Unit # : 8

2) File name: RNET

Type : Intermediate file

Contents : Network input data for TRAFFIC

Sequence : Titles, comments,parameters, size and network data. (See file description in Appendix B and TRAFFIC publication).

Unit # : 11

WORK FILES : 1) Eile name: RNET1

Type : Work file

Contents : Road network, nodes numbered for TRAFFIC

Sequence : Unsorted. In same sequence as GVRD inventory file

Unit # : 3

2) File name: RNET2

Type : Work file

Contents : Road network,nodes renumbered for TRAFFIC

Sequence : Sorted by link origin and destination numbers

Unit # : 10

d) File name: SIZFIL

Type : Work file

Contents : SIZE record for TRAFFIC

Sequence : 1 record only

Unit # : 9

PROCEDURE : In the following description, the names in the left hand column are subroutines which contain code for the section described to the right.

1)	RDCENT	Read centroid list from file RLIST.
		For each centroid:
	NPACK2	- Transform identifier to internal packed form (See Appendix A)
	RDCENT	- Add transformed identifier to list of nodes.
2)	RDMINI	Read turning node identifiers from file RINV.
	NPACK3	Transform turning nodes to internal packed form.
	QSORT	Sort transformed turning nodes
	RDMINI	Add to node list following centroids
3)	RDORIG	Read in link origin nodes.
		For each link origin node which is not a turning node:
	NPACK2	- Transform node to internal packed form
	RDORIG	- Add transformed node to node list Assign node list entry number to the link origin node
4)	WRNODL	Write transformed node list to file RNOD
5)	RDOVOL	Read link origin, destination and observed volume (vehicles) from file RLINK
	PTNODE	Transform link origin and destination nodes to internal number using node list
	RDOVOL	Enter link and volume in table (1 or 2 directions depending on screen line specification)
	RSORT	Sort links by origin and destination node numbers.
6)	TRANOD	Write SIZE record on work file SIZFIL.
		For all road links in file RINV:
		- read in link data
	NPACK2 QCEN	- Transform origin and destination node identifiers to number in node list

TRANOD - Determine if link is in CBD or on North Shore

TRANOD - Check that turning links have function = zero

DELFN - Determine delay function number and free flow speed

GTDVOL - Pick up observed volume, if any

TRANOD - Write link on file RNET1

7) TRANOD Write end file on RNET

8) Terminate (STOP 123)

9) Standard sort: Sort file RNET1 by origin node and destination node onto file RNET2

10) MERGEN. Copy file RTIT to file RNET

Copy file SIZFIL to file RNET

Copy file RNET2 to file RNET

Write end file on file RNET

Terminate

Note 1) The code for step 1 through 8 is contained in program MRPREP itself. Step 9 is the standard system sort. The code for step 10 is contained in program MERGEN.

2) Printing of the input data and certain debugging data in MRPREP is controlled by 2 switches

PRSW Print input data and output

DEBUG Print debugging output

The switches are set in the block data statement in MRPREP. TRUE causes printing.

3) Unit numbers are set in the BLOCK DATA statements in MRPREP and MERGEN

C1.1 DELFN.

Subroutine DELFN determines the free flow travel speed and delay curve number, from information contained in RINV, for each network link.

a) Free flow speed.

This is calculated from information on signals, link length and legal speed limit on the link. The following information is extracted from RINV:

- category of link (1,...,6)
- number of signals of each type on link
- link length

Link category determines the speed limit on link; for categories 1,...,6 the respects speed limits are 55, 35, 35, 30, 30, 18 (mph). It also determines the green/cycle ratio for automatic signals; they are respectively 0.6, 0.6, 0.5, 0.5, 0.3, 0.2.

Additional parameters are required to calculate the speed and may be modified by the user in the data statements of the subroutine. These parameters are:

- vehicle acceleration rate (ACC) (ft/sec/sec) assumed to be 6 ft/sec/sec.
- vehicle deceleration rate (DEC) (ft/sec/sec) assumed to be 4 ft/sec/sec.
- duration of automatic signal cycle (CYCLE) (sec) assumed to be 70 secs. for each link category
- cycle time for pedestrian automated signal (CYCPED) (secs), assumed to be 100 secs.
- duration of walk time on pedestrian automated signal (RPED) (secs), assumed to be 20 secs.
- cycle time for school crossing (CYCSCH) (secs) assumed to be 200 secs.
- duration of walk time at school crossing (RSCH) (secs) assumed to be 20 secs.

The free flow speed calculation is not very sensitive to changes in these variables so that approximate average estimates may be used. The calculation

of delay due to the presence of signals on the link assumes the following:

- that vehicles arrive randomly at the signal,
- a vehicle decelerates from the speed limit and accelerates to the speed limit if it stops at a signal.

b) Delay curve number

BPR type curves are used in TRAFFIC to compute link travel time as a function of assigned link volumes. These curves have the functional form

$$t = t_0 [1+\alpha_\ell (\frac{v}{c})^{\beta_\ell}]$$

where t = link travel time,

t_0 = free flow travel time,

v = link volume,

c = link capacity.

α_ℓ, β_ℓ are parameters determining the character of the delay curve number ℓ. This number is determined for each link and depends on the link category (1,...,6), number of lanes and if the link is CBD or non-CBD. Values for α and β for each delay curve may be modified by the user in the BLOCK DATA subprogram of TRAFFIC.

At present 24 different delay curves may be used: these are described in TABLE C1.1

TABLE C1.1

Delay Curve Categories

Delay curve number	Link type	Number of lanes	CBD or non-CBD
1	1		non-CBD
2	1		CBD
3	2	1	non-CBD
4	2	2	non-CBD
5	2	3	non-CBD
6	2	1	CBD
7	2	2	CBD
8	2	3	CBD
9	3	1	non-CBD
10	3	2	non-CBD
11	3	3	non-CBD
12	3	1	CBD
13	3	2	CBD
14	3	3	CBD
15	4	1	non-CBD
16	turning link		
17	4	2	non-CBD
18	4	3	non-CBD
19	4	1	CBD
20	4	2	CBD
21	4	3	CBD
22	5		
23	6		
24	centroid connector		

C.2. Program TRAFFIC

C.2.1 User supplied functions in TRAFFIC

a) UCOST

This function calculates the link travel time from the assigned link volume, free flow speed and link capacity. The BPR functional form for the delay curve is used: the link travel time is given as

$$t = t_o \left[1+\alpha_\ell \left(\frac{v}{c}\right)^{\beta_\ell}\right] \qquad (C1)$$

where t = link travel time

t_o = free flow travel time

v = link volume

c = link capacity

α_ℓ, β_ℓ are parameters for delay function ℓ.

b) OBJCNS, SSTRAV

These functions calculate the value of the objective function for a given set of link volumes. OBJCNS is the flow independent term and SSTRAV the flow dependent term. The objective function is given by

$$\sum_a \int_0^{v_a} t_a(v)dv$$

where v_a is the volume on link a and $t_a(v)$ is the delay function for link a. For delay curves of the form C1, the constant term is zero and the flow dependent term for each link is

$$t_o v \left[1+\frac{\alpha}{\beta+1}\left(\frac{v}{c}\right)^{\beta}\right]$$

c) BLOCK DATA subprogram

This contains values for α_ℓ, β_ℓ; ℓ=1,...24, and for each ℓ value a capacity is assigned to the link. This capacity was estimated from capacity data

describing each link type (1,...,6) at level of service E. At present BPR values are used for α and β (α=0.2, β=4.0) with the exception of links in the CBD (α=0.4, β=4.0). It is possible that these values will be refined by further model calibration.

C.2.2 Subroutine NULAFX

PURPOSE : Correct number of lanes for one way links.

The GVRD road inventory file contains the total number of lanes on a road section specified as a link, regardless of whether the link is 1 way or 2 way. The file does not contain any indicators for 1 way or 2 way for each link. The front end program MRPREP assumes all links are 2 way and assigns a number of lanes equal to the total number divided by 2, thereby introducing an error for 1 way streets. This error is corrected in TRAFFIC by calling subroutine NULAFX after the road network has been read in but before the traffic assignment is made.

INPUT : Vector	Contents
NOLAB(N)	Link number of first link with origin N (TRAFFIC sequence) N=1,NNODE
NODLST(N)	Packed representation of node N as described in Appendix A
ND(L)	Destination node number (TRAFFIC sequence) of link L (TRAFFIC sequence), L=1,NLINK
NULACO(L)	Number of lanes x 1000 plus delay curve number for link L (TRAFFIC sequence).

OUTPUT : a)

Vector	Contents
NULACO(L)	Corrected number of lanes x 1000 plus delay curve number for link L.

b) A message for every link for which the number of lanes has been corrected.

PROCEDURE: The procedure consists of scanning the links in the network and for each link searching for a link in the reverse direction. If none exists the original link is one way.

The procedure is performed once for each (origin) node N,N=1,NNODE.

1. Pick up first link with origin N. Set equivalent destination NN equal N.
2. If N is a turning node, transform to a destination in NN
   - get packed representation for N
   - transform to an equivalent destination: NO→SI, EO→WI, SO→NI, WO→EI
   - search NODLST for this destination (routine QCEN). If not found, all links from this origin are one way, set a switch. If found, set NN to entry in NODLST.
3. For each link (J) with origin node N
   - 3.1 Pick up destination node of link, N1
   - 3.2 If N1 is a turning node, transform to equivalent origin: SI→NO, WI→EO, NI→SO, EI→WO and search NODLST to find node number N1 of this origin (routine QCEN). If origin does not exist link J is one way, go to step 3.4
   - 3.3 For each link (K) with origin node N1,
     1. Pick up destination node ND(K). If destination node is equal to origin N, link is 2 way, i.e.
        $origin_1$ N=ND(K) $destination_2$
        $destination_1$ N1=N1 $origin_2$

        go to step 3.5

3.4 (No link with origin 1 = destination 2 and destination 1 = origin 2). Double number of lanes for link J.

3.5 Increment J.

Note: The program code may contain comments which describe the transformations erroneously. (Steps 2 and 3.2).

C.3 Program: CRSIGN

PURPOSE : Create a file with format of the GVRD file RSIGN containing the results from TRAFFIC

INPUT : 1) File name: RNET

Type : Intermediate file

Contents : Network input data for TRAFFIC

Sequence : Titles, comment, parameters, size and network data (see file description in Appendix B and TRAFFIC publication)

Unit # : 11

2) File name: RNOD

Type : Intermediate file

Contents : Vector of transformed GVRD identifiers

Sequence : 1 record only

Unit # : 8

3) File name: RSOL

Type : Intermediate file

Contents : Link volumes and times predicted by traffic

Sequence : See file description in Appendix B

Unit # : 17

OUTPUT : File name : RSIGN

Type : GVRD file

Contents : Predicted link volumes and times, network description, node identifiers

Sequence : See file description in Appendix B

Unit # : 15

PROCEDURE: In the following description, the names in the left hand column are subroutines which contain code for the section described to the right.

1) CRSIGN	Copy comment from RSOL to RSIGN (assignment identification)
2)	Read SIZE record from RNET
CDATE	Get date and time
CRSIGN	Write record 2 on RSIGN
3) RDNET	Read RNET and construct link origin indexes (NOLAB or JSTART, NOLAB2 or JEND, ND or IDEST)
CRSIGN	Write JSTART, JEND and IDEST vectors to RSIGN
4) INITND	Read node list from RNOD
CRIORD	Construct IORD, identifier order vector
CRSIGN	Write IORD to RSIGN
5) CREXT	Construct GVRD identifiers (right justified from node list)
CRSIGN	Write identifier vector to RSIGN
6) CRSIGN	Read predicted drivers from RSOL
	Double volume for 2 hours
	Write volume on file RSIGN
7) CRSIGN	Read predicted travel times, predicted passengers from RSOL
	Double passenger volume for 2 hours
	Write passenger volume on RSIGN
	Write travel times on RSIGN
8)	Terminate

Note 1) Unit numbers are assigned in the BLOCK DATA statements

2) Printing is controlled by switches PRSW and DEBUG as described for MRPREP.

APPENDIX D

Error messages from programs MRPREP and CRSIGN

This appendix describes the messages printed by programs MRPREP and CRSIGN.

The messages have the following format:

xxxni Text

where xxx = program module number

n = number of message within module

i = I for Informative messages (no error)
= E for Error messages

Text = message text

The messages and their explanations follow in sequence according to xxxn. Where no Action is indicated, the program continues normally and no action by the user is required.

1000I TRAFFIC FILE COMPLETE ON UNIT n

Explanation: The road network file (RNET) has been successfully created on unit n.

1103E CENTROIDS OUT OF ORDER n1 n2

Explanation: The list of centroids, file R.LIST is not in ascending order. n1 is greater than or equal to n2.
Action: Execution of MRPREP is terminated. Correct R.LIST and rerun.

1204E TOO MANY LINKS n

Explanation: The road inventory file (R.INV) contains more links than the maximum allowed (n).
Action: Execution of MRPREP is terminated. To increase the capacity of the program, increase dimension of N1 and insert dimension in MXLINK

1301E INVALID NODE NUMBER nnnnx

Explanation: See message 1201E

1302E TOO MANY NODES n

Explanation: The number of centroids, turning nodes and road nodes exceeds the program capacity (n).
Action: Execution of MRPREP is terminated. To increase the program capacity, increase dimension of NODLST and insert dimension in MXNODE.

1410E SCREEN LINE iii LINK kk NODE NUMBER NOT IN NETWORK nnnnxtt

Explanation: Self explanatory
Action: The link is ignored.

1402I NO LINKS IN SCREEN LINE FILE

Explanation: Self explanatory.

1501E ERROR IN CONVERSION OF nnnnxtt

Explanation: The conversion of the turning node indicated was unsuccessful. This is due to a program error.
Action: Consult a programmer.

1502E NO PATH FROM NODE nnnnx

Explanation: Road node nnnx occurs on the road inventory file as a destination only (and is not a centroid).
Action: The internal node number is set to zero.

1508I TURNING LINK TYPE NOT ZERO nnnxtt mmmmyuu nn

Explanation: Turning links must have link type zero (blank).

1831E INVALID NODE NUMBER nnnnx

Explanation: See message 1201E

1841E INVALID TURNING NODE NUMBER nnnnxtt

Explanation: The node number nnnnxtt contains an invalid turning identifier tt. This identifier must be NI, NO, SI, SO, WI, WO, EI or EO.
Action: The turning node is assigned the internal number zero.

1104E TOO MANY CENTROIDS n

Explanation: There are more centroids (file R.LIST) than the number of nodes allowed (n).
Action: Check for an error on R.LIST file. To increase capacity of program, increase dimension of NODLST and insert dimension in MXNODE.

1201E INVALID NODE NUMBER nnnnx

Explanation: The node number nnnx found on the road inventory file cannot be converted to internal form either because x is other than A-Z, 0-9 or nnnn is blank or zero.
Action: Execution of MRPREP is terminated. Correct or change the node number and rerun.

1202E TURNING NODE nnnnxtt INCOMPATIBLE WITH LINK NODE mmmmy

Explanation: The turning node nnnnxtt found on the road inventory file is not compatible with the corresponding road node in the same record, i.e. nnnnx ≠ mmmmy.
Action: Execution of MRPREP is terminated. Correct the node number and rerun.

1203E TOO MANY TURNING NODES n

Explanation: There are more turning nodes than the number allowed (n).
Action: Check for an error on R.INV file. To increase capacity of the program, increase dimension of NODLST and insert dimension in MXNODE.

1851I EXTERNAL NUMBER TABLE WRITTEN ON UNIT nn, LENGTH mmmmm

Explanation: The table of node identifiers found on the centroid (R.LIST) and road inventory (R.INV) files, transformed as described in Appendix A, has been written on file RNOD which has unit number nn. The length of the table written was mmmmm.

1861E EXPECTING A DIGIT, FOUND -a- IN CONVERSION OF mmrrt

Explanation: The node identifier mmrrt is not a turning node but contains a non numeric character in position rr.

Action: The character is converted to zero.

2101E NUMBER OF NODES ON EXTERNAL NUMBER VECTOR AND NETWORK INCOMPATIBLE nnnnn mmmmm

Explanation: The number of transformed node identifiers on the file RNOD (nnnn) must be the same as the number of nodes read from the network file RNET (mmmmm).
Action: Check that the files were created in the same run of MRPREP.

3103E UNEXPECTED EOF ON UNIT nn

Explanation: End of file was encountered when attempting to read predicted values from TRAFFIC file SOLFIL on unit nn.
Action: Execution of CRSIGN is terminated. Check that the file was created by TRAFFIC.

3105I RSIGN COMPLETE ON UNIT nn

Explanation: File RSIGN (RSOL) has been successfully created on unit nn.

3107E SIZE CARD MISSING: aaaa

Explanation: File RNET as read by CRSIGN, does not contain a SIZE card as the fifth record. (See description of RNET in appendix B).
Action: Check for an error in control cards. File RNET, output from MRPREP must be input to CRSIGN.

3161E ERROR CONVERTING iiiiiii nnn

Explanation: See Appendix A. During conversion of the transformed identifier iiiiiii an error was encountered in the conversion from binary to character form (routine BTD). This is a program error.
Action: Consult a programmer.